جامعة الملك سعود
King Saud University

Regulation of Blood Pressure

Index:
Red: important Grey: extra information Green: doctor's notes yellow: numbers
Purple: only in female slides Blue: only in male slides

Physiology Team437

Physiology 437 teamwork

MED437
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OBJECTIVES

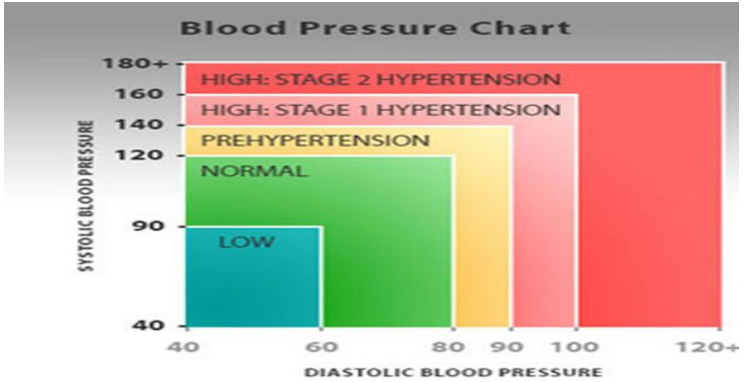
by the end of this lecture you will be able to:

- ☐ List the short, intermediate and long-term mechanisms regulating ABP.
- ☐ Understands how baroreceptors prevent significant changes in BP and why they act for short-term control.
- ☐ Understand why chemoreceptors work under emergency conditions to control BP.
- ☐ List the anatomical components of baroreceptors/chemoreceptors.
- ☐ Explains the role of the kidney in the long-term regulation of ABP.

Regulation of Arterial Blood Pressure

Importance of regulation arterial blood pressure :

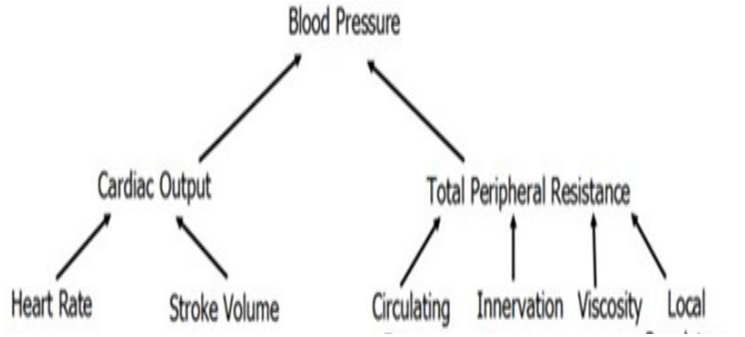
- Maintaining BP is important to ensure a steady blood flow (perfusion) to the tissues
- Inability to regulate blood pressure can contribute to diseases.



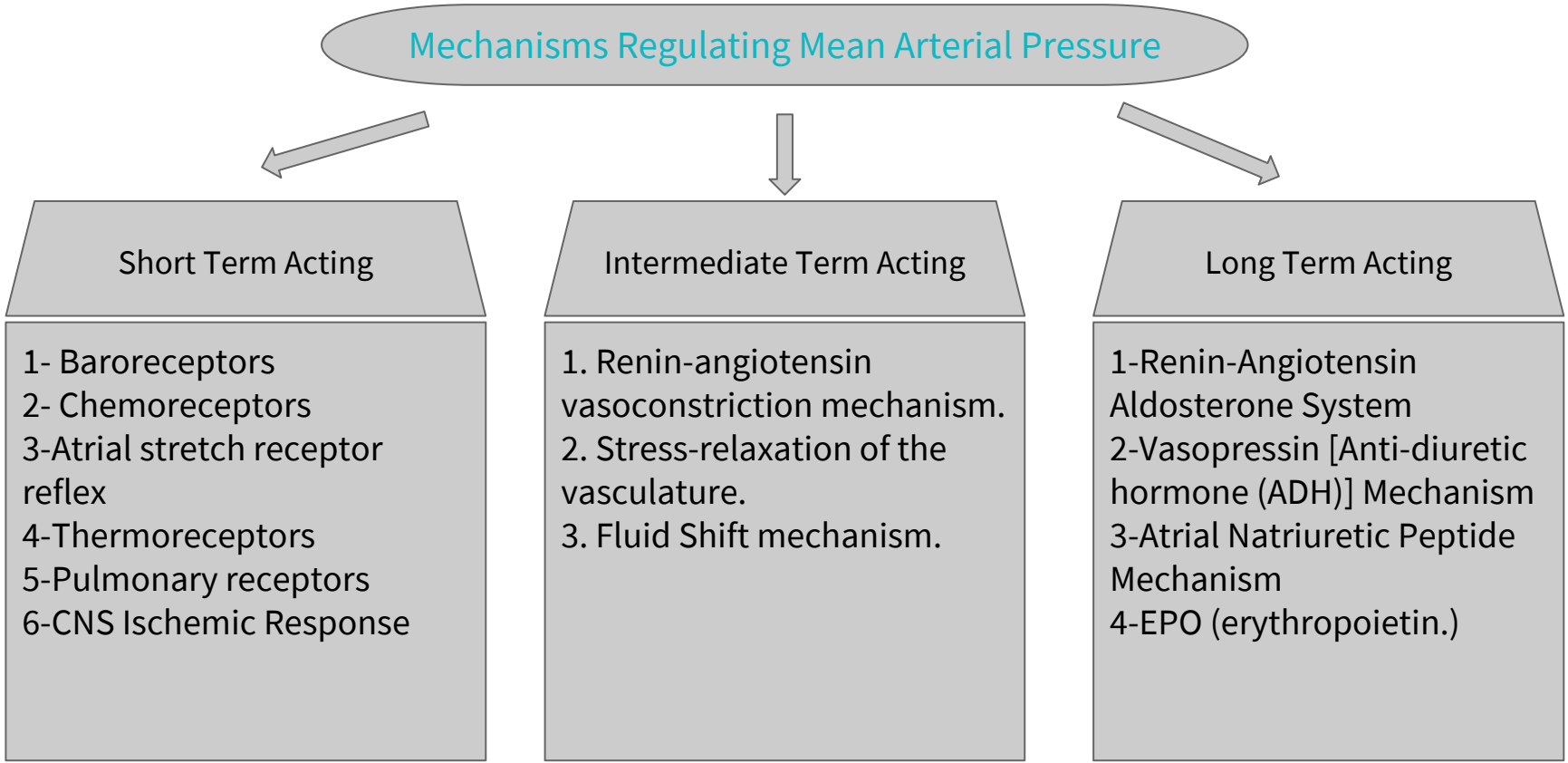
In order to regulate the blood pressure, determining factors should be regulated:

1. Cardiac Output.
2. Peripheral Resistance.
3. Blood Volume.

Changing in one of them can affect blood pressure.



Mechanisms Regulating Mean Arterial Pressure

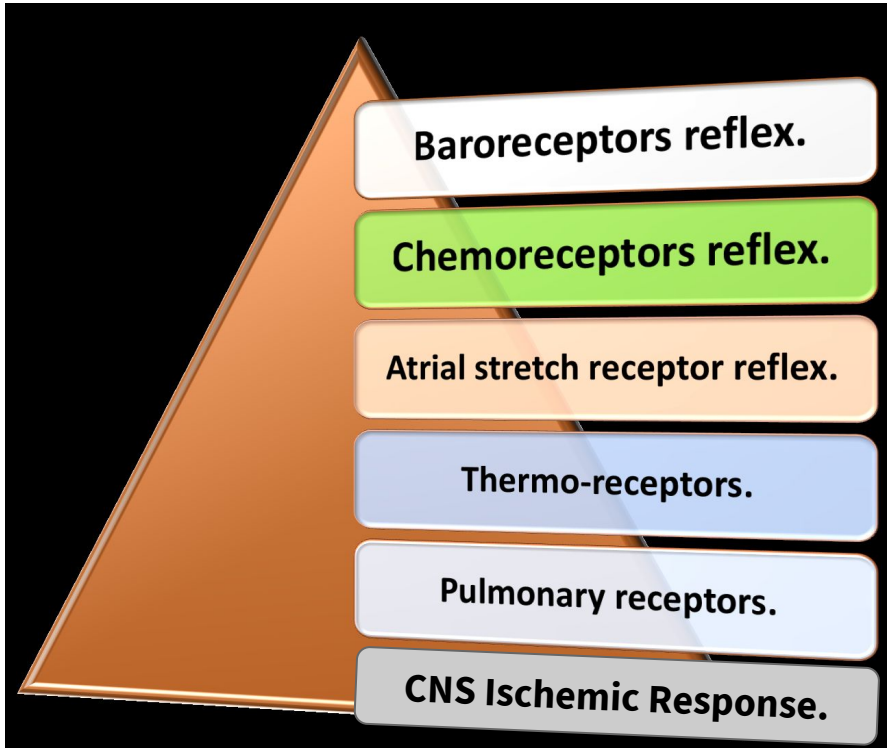


Rapidly Acting Control Mechanisms "Short Term Acting"

Acts within sec/min.
Concerned in regulating CO & PR.

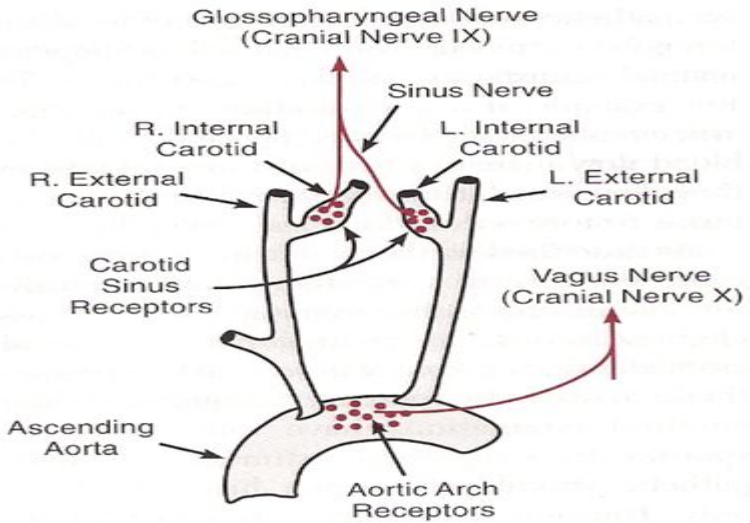
Reflex mechanisms that act through autonomic nervous system "Centers in Medulla Oblongata":

- Vasomotor Center (VMC)
  - Sympathetic nervous system
- Cardiac Inhibitory Center (CIC)
  - Parasympathetic nervous system



The Baroreceptors
” Baroreceptor reflex”

- Mechano-stretch receptors.
- Located in the wall of carotid sinus & aortic arch.
- Fast & neurally mediated.
- These receptors provide information to the cardiovascular centres in the medulla oblongata about the degree of stretch with pressure changes.
- Provide powerful beat-to-beat control of arterial blood pressure.
- Stimulated in response to blood pressure changes ”Mean Arterial Pressure” MAP.

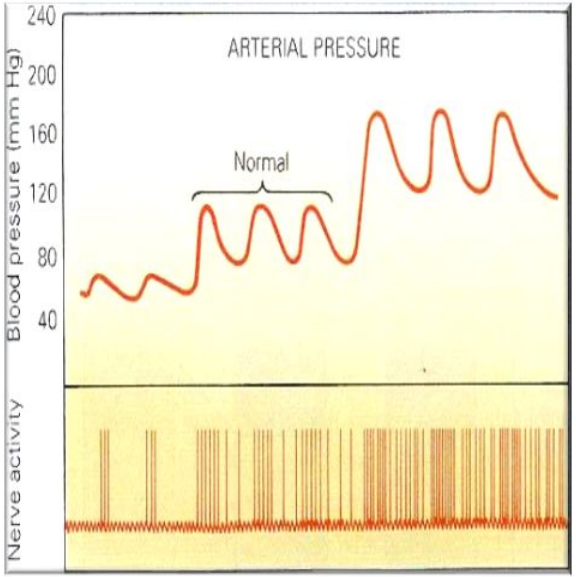


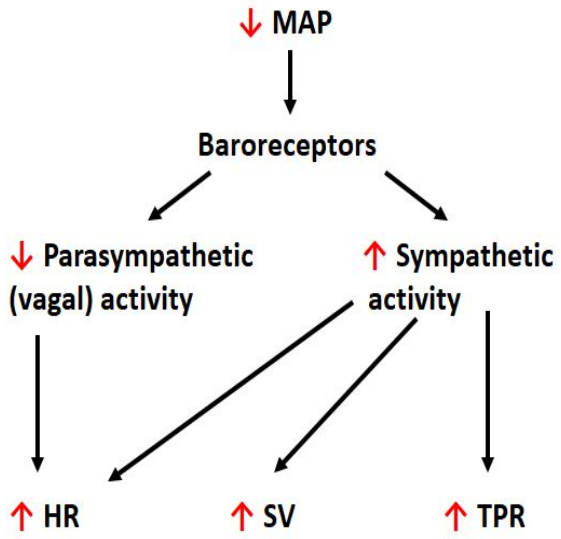
The impulses of the aortic receptors are carried by vagus nerve (Cranial Nerve X)
The impulses of the carotid receptors are carried by glossopharyngeal nerve (Cranial Nerve IX)

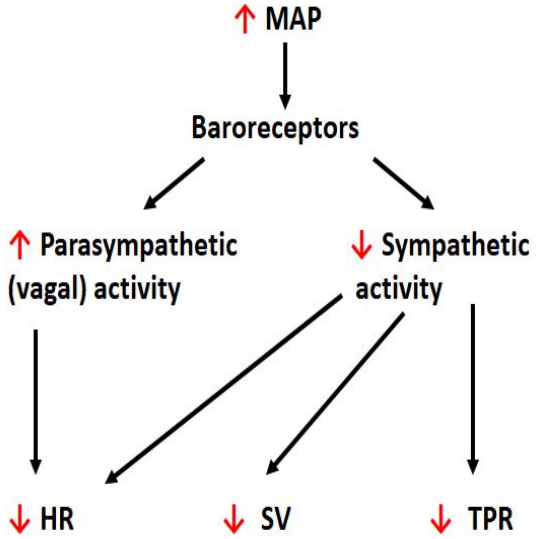
Firing Rate of Baroreceptors

Increased BP" MAP" → Increases their rate of activity" Firing rate"

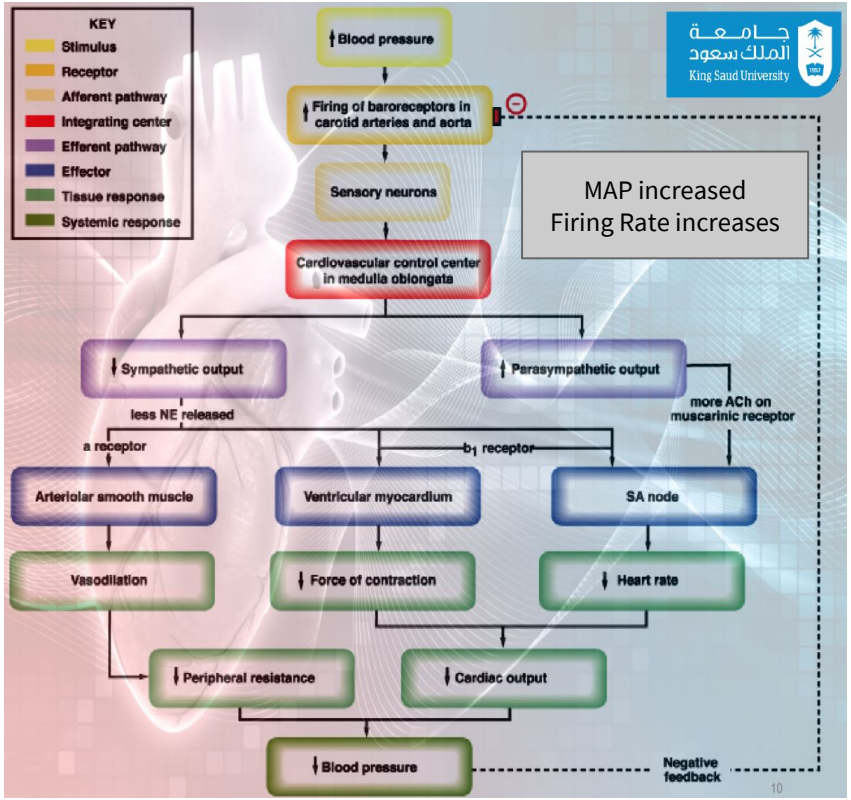
Decreased BP "MAP" → Decrease their rate of activity" Firing rate"

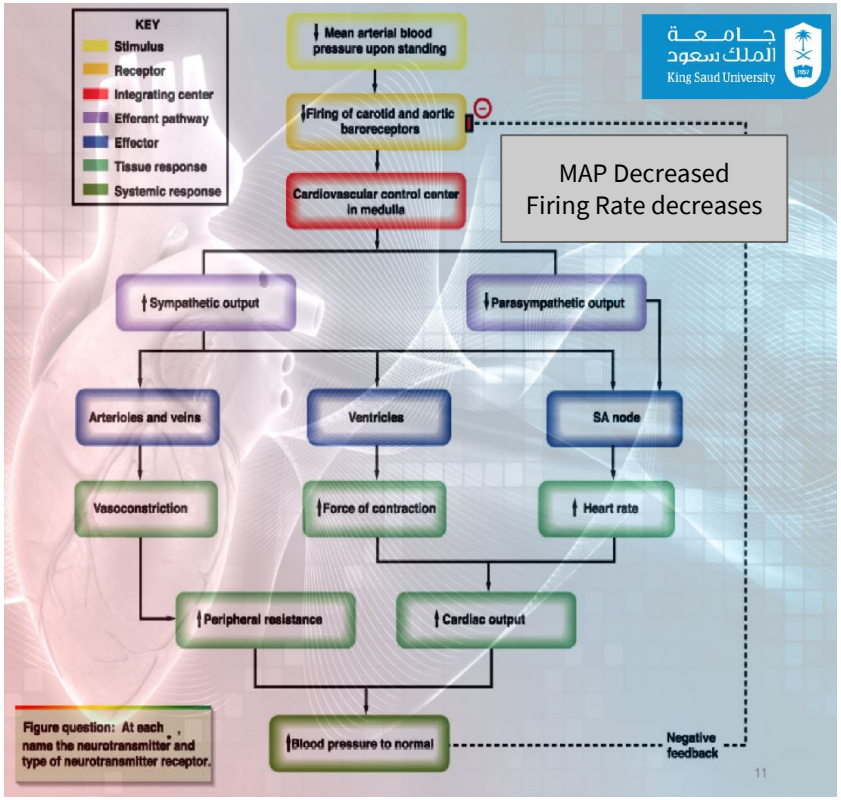






Cont. Firing Rate of Baroreceptors





Baroreceptor Reflex Mechanism During Changes in Body Posture

- Immediately on standing, arterial pressure in the head and upper part of the body tends to fall?**cause loss of consciousness.**
- Falling pressure at the baroreceptors elicits an immediate reflex,resulting in **strong sympathetic discharge** throughout the body.
- This minimizes the decrease in pressure in the head and upper body.

Chemoreceptor Reflex

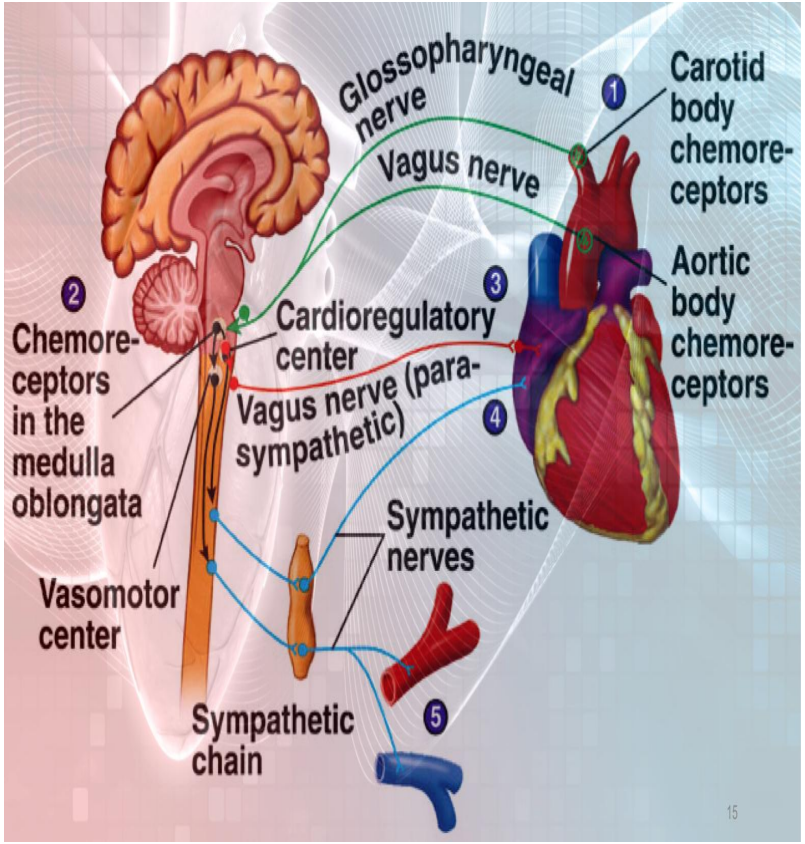
- Closely associated with the baroreceptor pressure control system.
- **Chemoreceptor reflex** operates in much same way as the baroreceptor reflex, **EXCEPT** that chemoreceptors are chemo-sensitive cells instead of stretch receptors.

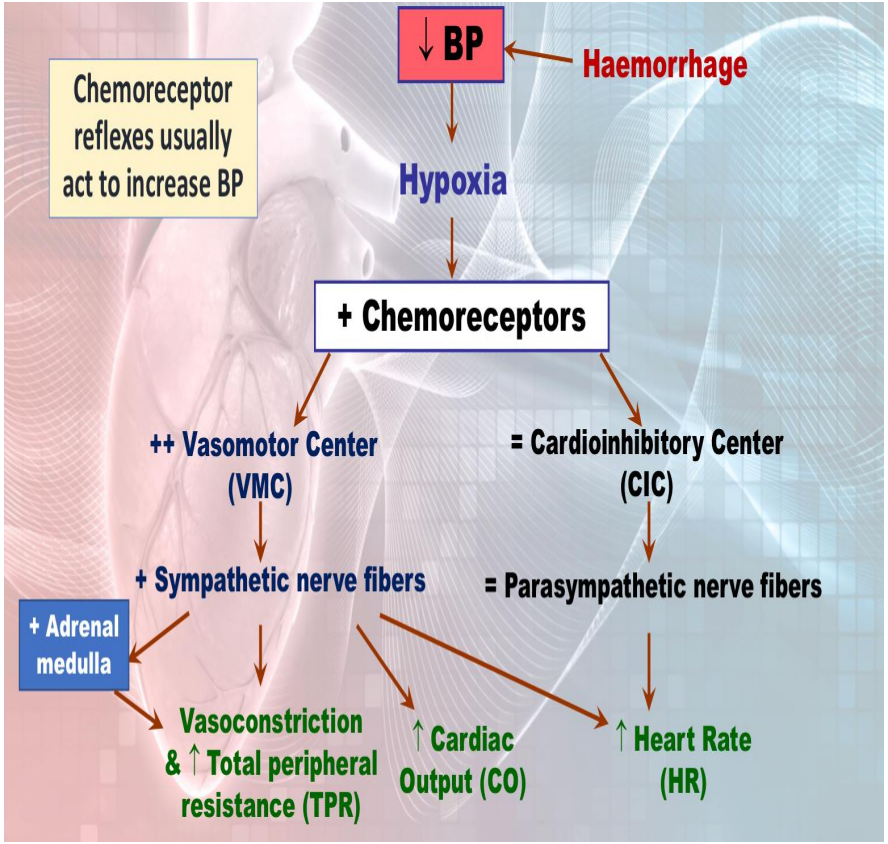
Types of Chemoreceptor Reflexes

Peripheral chemoreceptors:
1-Sensory receptors located in carotid & aortic bodies.
2-Sensitive to Oxygen(↓) ,carbon dioxide (↓ or ↑), and pH (↑ or ↓)
3-Chemoreceptors' stimulation excite nerve fibers, along with baroreceptor fibers.

Central Chemoreceptors
1-Sensory receptors located in the medulla itself.
2-Very sensitive to carbon dioxide excess(↑) and pH (↓) in medulla.

Peripheral chemoreceptor reflex





CNS Ischemic Response: "Last ditch stand" pressure control mechanism

- It is not one of the normal regulatory mechanisms for ABP.
- It operates principally as an **emergency pressure control system** to prevent further decrease in arterial pressure.
- It acts **rapidly & very powerfully** whenever blood flow to the brain decreases dangerously close to the lethal level.
- Local concentration of **CO2 increases** greatly.
- This has an extremely potent effect in stimulating the sympathetic vasomotor nervous control areas in the brain's medulla.
- When MAP < 20 mmHg → cerebral ischemia of vasomotor center → strong excitation of vasomotor center (due to accumulation of CO2, lactic acid) → strong vasoconstriction of blood vessels including the kidney arterioles.

Atrial Stretch Volume Receptors:

ONLY in female slides

- **Atrial stretch receptor reflex:**
  - Increased venous return ➡ ++ atrial stretch receptors ➡ **reflex vasodilation & decreased ABP**

ONLY in male slides

Receptors in large veins close to heart, walls of the atria (response of blood volume).
An increased blood volume → stretch of atria → activate atrial volume receptors → sensory afferent nerves to medulla → inhibiting the cardiovascular centre.
This results into decreased blood volume through:

a) **↓ sympathetic drive to kidney:**
   i) → dilate afferent arterioles → ↑ glomerular capillary hydrostatic pressure → ↑GFR → ↓ blood volume (towards normal).
   ii) ↓ renin secretion (Renin is an enzyme which activates angiotensinogen in blood).
      - Inhibition of renin secretion → inhibit RAAS → inhibit aldosterone production → ↓ Blood volume (towards normal)

b) **↓ ADH secretion** → ↓ blood volume (towards normal).

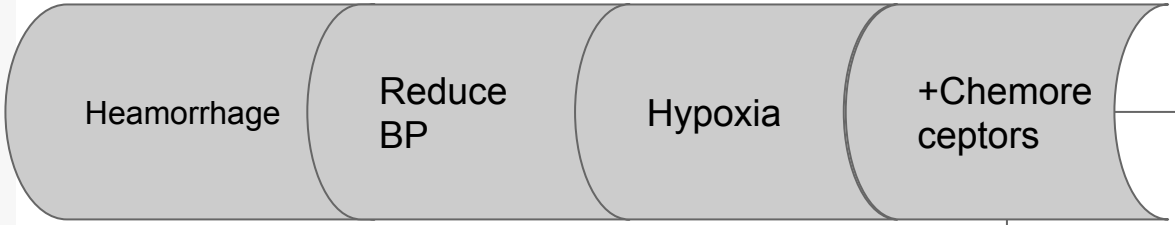
c) **↑ Atrial Natriuretic Peptide** (ANP) causes loss of blood volume.

Other Vasomotor Reflexes:

ONLY in female slides

- **Pulmonary receptors:**
  - Lung inflation ➡ **vasoconstriction**

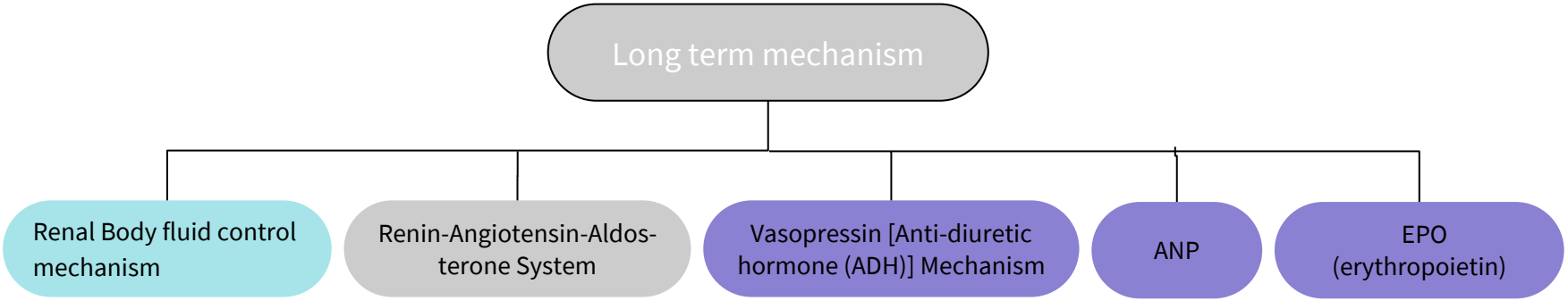
- **Thermo-receptors:**
  - Exposure to heat ➡ **vasodilation**
  - Exposure to cold ➡ **vasoconstriction**



++Vasomotor Center (VMC)
↓
++Sympathetic nerve fibers
↓
1-stimulus adrenal medulla which lead to incresec vasoconstriction and TPR
2-increase cardiac output
3-increase heart rate

Cardioinhibitory Center (CIC)
↓
Parasympathetic nerve fibers
↓
Increase heat rate

LONG TERM REGULATION OF BLOOD PRESSURE (acting within days to months)



- Hormonally mediated.
- Takes few hours to begin showing significant response.

Renal Body fluid control mechanism

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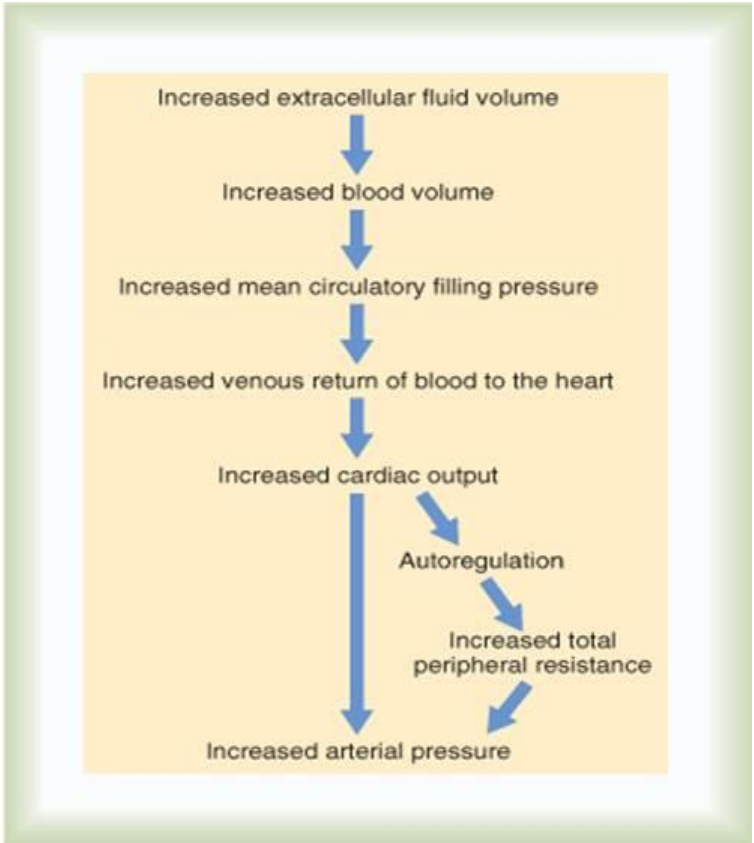

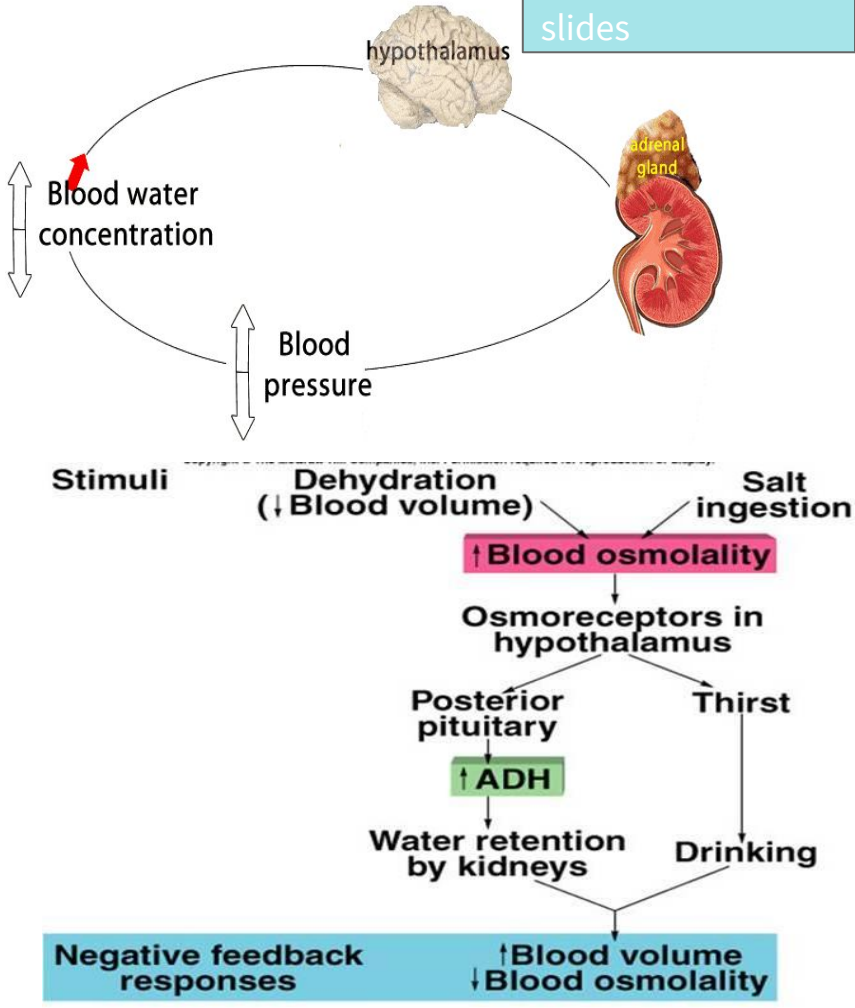

Renin – Angiotensin Aldosterone System

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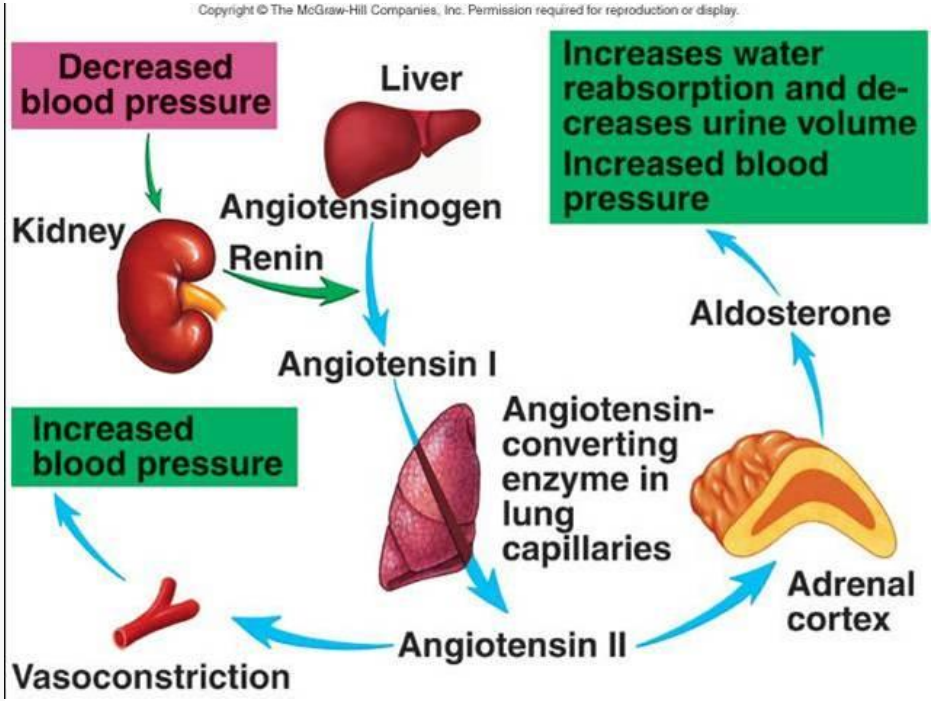
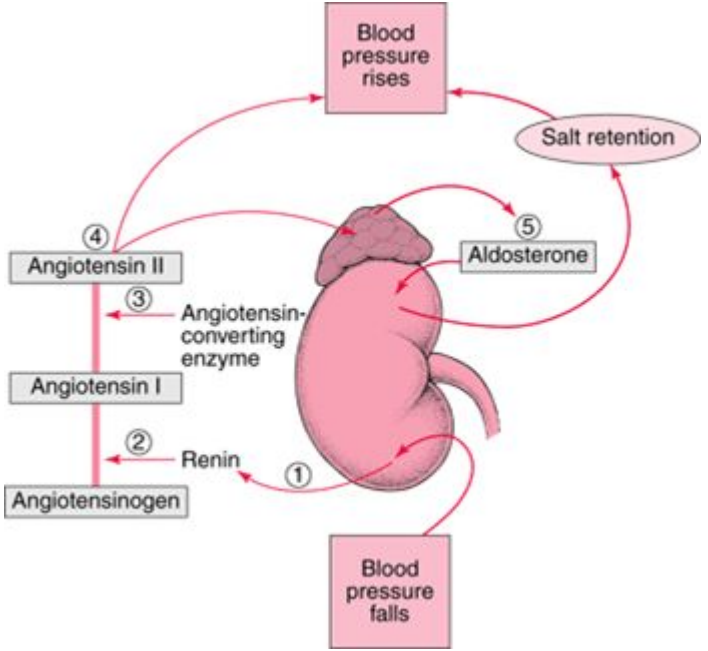
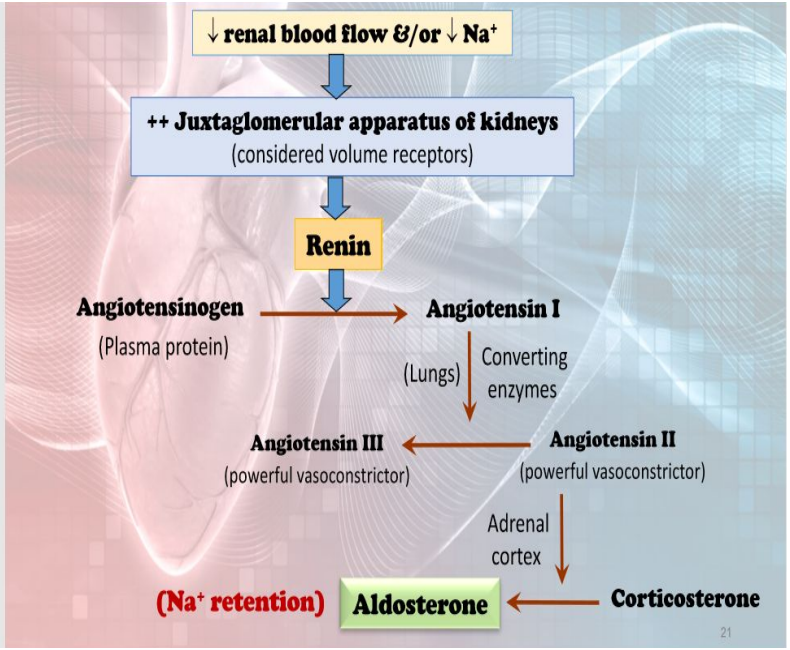




Renin – Angiotensin Aldosterone System



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Vasopressin [Anti-diuretic hormone (ADH)] Mechanism

- Hypovolemia & dehydration stimulates Hypothalamic Osmoreceptors.
- ADH will be released from posterior pituitary gland:

-Promotes water reabsorption at kidney tubules ↑ blood volume.
-Causes vasoconstriction, in order to ↑ ABP.

- Thirst stimulation.
- Usually, when secreted aldosterone is secreted.

ONLY in female slides

Atrial Natriuretic Peptide (ANP) hormone:

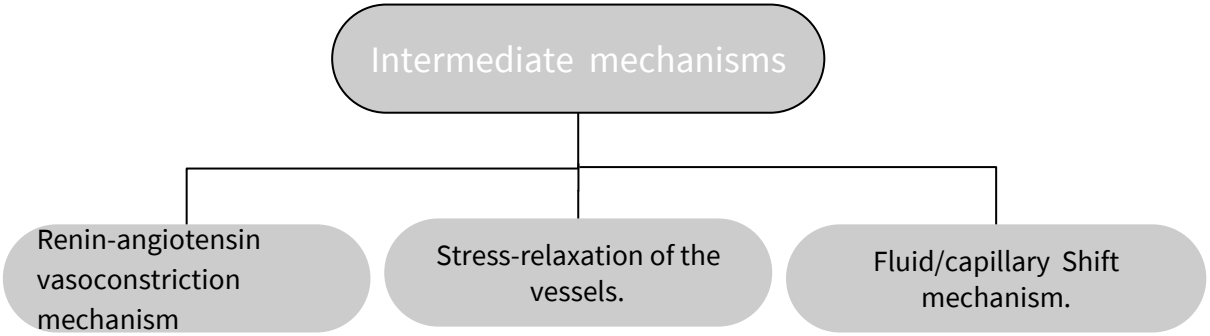
- Hormone released from cardiac muscle cells (wall of right atrium) as a response to an increase in ABP.
- Simulates an ↑ in urinary production, causing a ↓ in blood volume & blood pressure.

EPO (Erythropoietin)

- Secreted by the kidneys when blood volume is too low.
- Leads to RBCs formation → ↑ blood volume

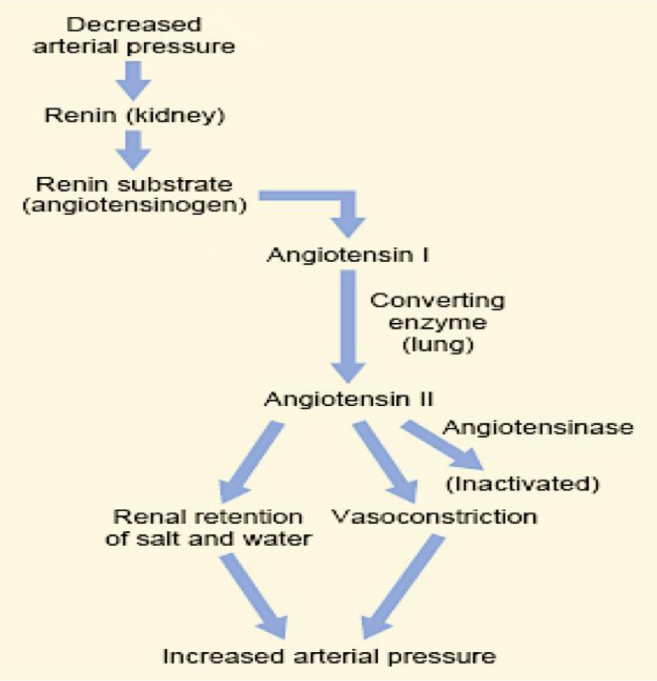
Intermediate Mechanisms:

Activated within 30 min to several hrs.



During this time, the nervous mechanisms usually become less & less effective.

1. Angiotensin Vasoconstriction System



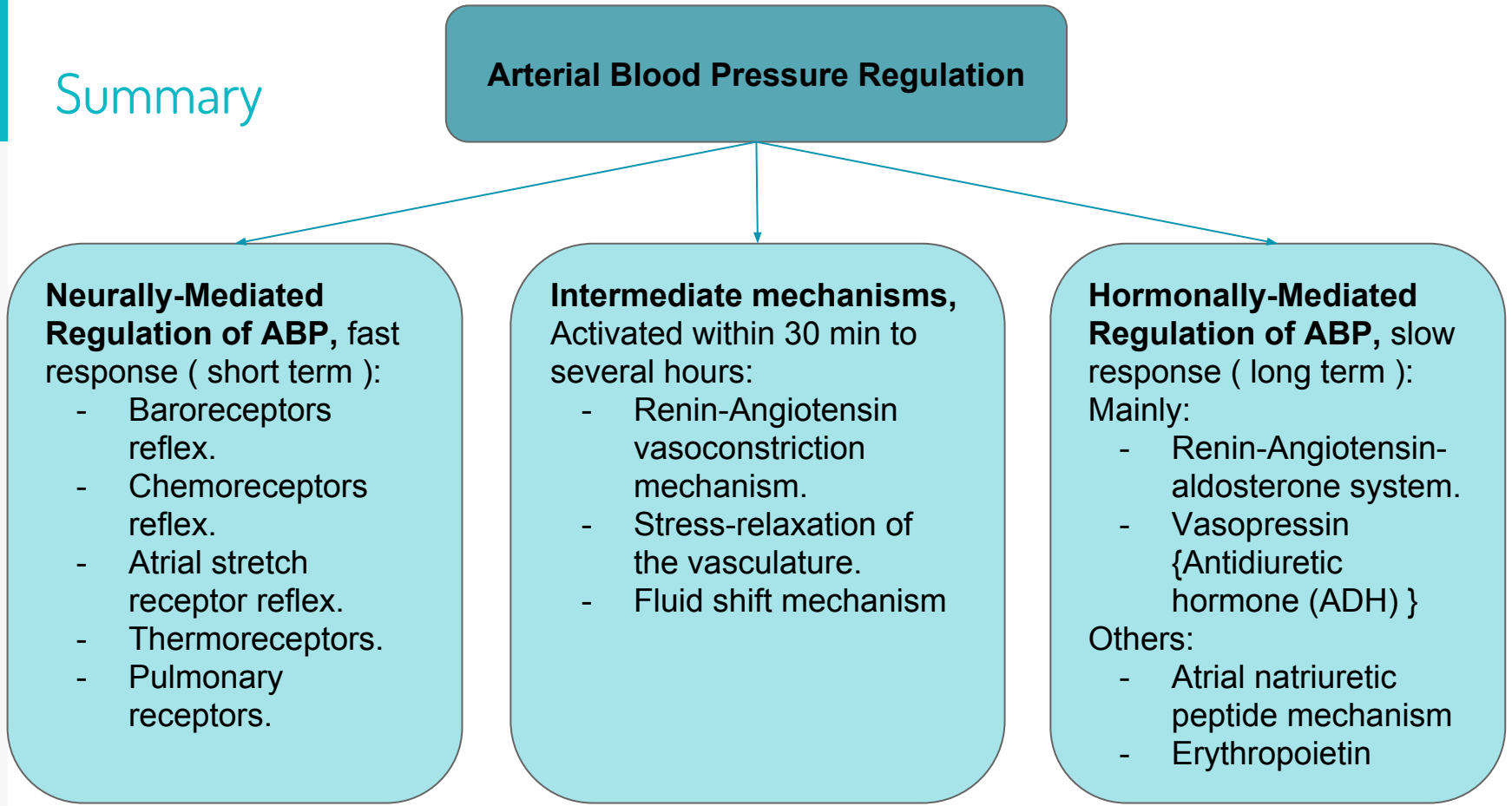
2. Fluid Shift Mechanism

- Movement of fluid from interstitial spaces into capillaries in response to ↓ BP to maintain blood volume.
- Conversely, when capillary pressure ↑ too high, fluid is lost out of circulation into the tissues, reducing blood volume as well as all pressures throughout circulation.

3. Stress-Relaxation Mechanism

- Adjustment of blood vessel smooth muscle to respond to changes in blood volume.
- When pressure in blood vessels becomes **too high**, they become stretched & keep on stretching more & more for minutes or hours; resulting in fall of pressure in the vessels toward normal.
- This continuing stretch of the vessels can serve as an intermediate-term pressure "**buffer**."

Summary


Arterial Blood Pressure Regulation
Neurally-Mediated Regulation of ABP, fast response (short term):
- Baroreceptors reflex.
- Chemoreceptors reflex.
- Atrial stretch receptor reflex.
- Thermoreceptors.
- Pulmonary receptors.
Intermediate mechanisms, Activated within 30 min to several hours:
- Renin-Angiotensin vasoconstriction mechanism.
- Stress-relaxation of the vasculature.
- Fluid shift mechanism
Hormonally-Mediated Regulation of ABP, slow response (long term):
Mainly:
- Renin-Angiotensin-aldosterone system.
- Vasopressin {Antidiuretic hormone (ADH) }
Others:
- Atrial natriuretic peptide mechanism
- Erythropoietin

Quiz

1.Chemoreceptors are stimulated when the MAP is lower than ?
A- 100 mmHg
B- 120 mmHg
C- 60 mmHg
D- 80 mmHg

2. Which one of the following is considered a long term regulation of blood pressure ?
A- capillary shift mechanism
B- renal body fluid control mechanism
C- chemoreceptors mechanism
D- baroreceptors reflex mechanism

3. Which one of the following mechanism play an important role in maintaining relatively constant blood flow to vital organs ?
A- capillary shift mechanism
B- renal body fluid control mechanism
C- chemoreceptors mechanism
D- baroreceptors reflex mechanism

1.C
2.B
3.D

Quiz

4.Which one of the following is hormonally mediated regulation of ABP ?
A- Atrial stretch receptor reflex
B- thermoreceptors
C- EPO
D- pulmonary receptors

5. Which one of the following true if the blood pressure increases ?
A- decrease firing of the baroreceptors in the carotid arteries and aorta
B- increase firing of the baroreceptors in the carotid arteries and aorta
C- increase sympathetic output
D- decrease parasympathetic output

6. In the central chemoreceptors the sensory receptors located in the ?
A- carotid bodies
B- aortic bodies
C- carotid & aortic bodies
D- medulla itself

4.C
5.B
6.D

Thank you for checking our work

Team Leader:

العنود سلمان

Male Team:

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سعد الهداب
سعود العطوي
سيف المشاري
عبدالجبار اليماني
عبدالرحمن آل دحيم
عمر الفوزان
فهد الحسين
نايف المطيري
نواف اللويمي
محمد الحسن
هشام الشايع
خالد العقيلي
سعد الفوزان
عبدالله الزيد
نواف اللويمي
عبدالمجيد الوردي
يزيد الدوسري

Female Team:

الآء الصويّغ
رناد المقرن
رهف الشنيبر
روان التميمي
روان مشعل
ريم القرني
ليلى الصباغ
فلوة السعوي
نورة بن حسن
نورة الحربي
نورة العثيم
مجد البراك
لينا العوهلي
عهد القرين
مها النهدي
مها بركة
سارة الفليج
هند العريعر
ريناد الغريبي
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Any questions?

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